January 3, 2014

Dr. Andrew Rawicz
School Of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Capstone Project Proposal for a *Plantar Foot Pressure Analysis System*

Dear Dr. Rawicz,

Please find the attached proposal for a *Plantar Foot Pressure Analysis System* by PresTrack, which describes a sensor equipped shoe insole to characterize the pressure distribution on the plantar surface of the foot during everyday tasks. Our goal at PresTrack is to create a system that is cost effective and provides reliable and repeatable results.

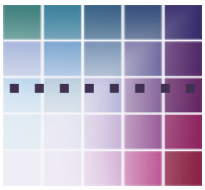
This proposal discusses the development of our system concept, as well as providing a concise background into the role of pressure in walking, standing and balance, and chronic disabilities such as plantar fasciitis. Within our proposal, we have also documented the fundamental design, budget, scheduling, and company/team organization.

With a vision to streamline affordable analysis technology and systems for all areas research and medical treatment, PresTrack is composed of five ambitious engineers dedicated to contributing to the biomedical community by means of innovative technology solutions to the current medical problems. Our team is eager to bring out the PresTrack System into the market as a new, more accessible standard for portable foot pressure systems.

If you have any inquiries or comments regarding this project, please feel free to contact Riddhi Bhide at 778.386.6115 or by email at rbhide@sfu.ca.

Sincerely,

Riddhi Bhide
Chief Executive Officer



Proposal for a Plantar Foot Pressure Analysis System

Riddhi Bhide **CEO**
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Navjot Randev **CCO**

Primary Contact	Riddhi Bhide, rbhide@sfu.ca
Submitted to	Dr. Andrew Rawicz (ENSC 440)
	Steve Whitmore (ENSC 305)
	School of Engineering Science
	Simon Fraser University
Issued Date	3 January 2014
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Imagine waking up everyday and not being able to take a single step without the clinching pain in your feet. This is a living reality for those suffering with plantar fasciitis. The plantar fascia aids in stabilizing the foot by absorbing the energy imposed on the heel with each heel strike, but can become the source of great pain with this characteristic inflammatory disease. Generally characterized as "inferior heel pain", its causes are difficult to infer due to its" multi-factorial nature." [1] A published study for converging on risk factors for plantar fasciitis found that obesity and prolonged strain on the feet due to body weight were one of the leading causes for this condition. [2]

Studies show that "Ten percent of the [population] in United States can experience this disorder [...and] 83% of these patients" are in the working age." [3] Traditionally diagnosed by a physician, most treatment is reactive in nature as plantar fasciitis is diagnosed using emerging symptoms such as foot pain. This demonstrates a need for an early diagnosis system as a part of a proactive and preventative treatment plan. At PresTrack we hope to deliver a solution to this problem with our *Plantar Foot Pressure Analysis System*.

Our system consists of a shoe-insert equipped with pressure sensors, integrated with a data collection and analysis unit supported by the ankle. Controlling the unit will be achieved using accompanying software that will allow the user to set a limited number of parameters for data collection, download the data for future use, and present the results in a clear and easy to understand manner.

PresTrack's budget for the research, development and implementation of this product is $984, and will be obtained primarily through the Engineering Student Society Endowment Fund (ESSEF) and the Wighton Fund, with PresTrack absorbing remaining costs. The funding will be invested into research, development and prototyping of a *Plantar Foot Pressure Analysis System*.

We propose a 12 week development time. The first phase, of approximately three weeks, comprising of initial research, funding proposal and ordering parts. The second phase of five weeks will entail rudimentary testing, establishing a proof of concept, and developing the design modules of the project. The next two weeks will include integration, troubleshooting, and any necessary redesigning. The final week will be used to prepare for presentation. The product is set to be released on April 2, 2014, and PresTrack aims to ensure that along with the introduction of our system, we can set the new, more accessible standard for diagnosing Plantar Fasciitis in its early stages.

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Diabetic Ulcers	Neurogenic ulcers, also known as diabetic ulcers, are ulcers that occur most commonly on the bottom of the foot [5]
MCU	Microcontroller Unit
Plantar	an anatomical reference; of or relating to the sole of the foot
Plantar Fasciitis	Plantar fasciitis is inflammation of the thick tissue on the bottom of the foot. This tissue is called the plantar fascia. It connects the heel bone to the toes and creates the arch of the foot. [4]

BACKGROUND

As the primary point of contact with the ground, the foot experiences an array of forces and deformations throughout day-to-day activity and locomotion, and along with the largest change in force for a given period of time compared to any other segment of the body.[6] The ability of the foot to bear weight pain-free and provide support during standing, walking, running, or jumping can be impaired due to chronic and/or abnormal pressure distributions along the plantar surface of the foot.

The effects of these pressure distributions are widely studied in athletics, designing footwear to provide the best mechanical advantage; the elderly, in the form of increased risk of falling leading to severe secondary complications; persons diagnosed with plantar fasciitis, resulting in persistent discomfort affecting one's quality of life; as well as diabetic patients at risk of developing diabetic ulcers on the foot.

Plantar fasciitis in particular is an inflammatory condition of the plantar fascia (shown in figure 1 below) affecting 1 in 10 persons in the United States. [3] A potentially debilitating, this condition affects young and old, working citizens and athletes alike. Plantar fasciitis is commonly characterized by sharp pain in the heel, however the causes aren't so common and can range from obesity, lifestyle, footwear, and abnormal pressure distributions along the bottom of the foot.

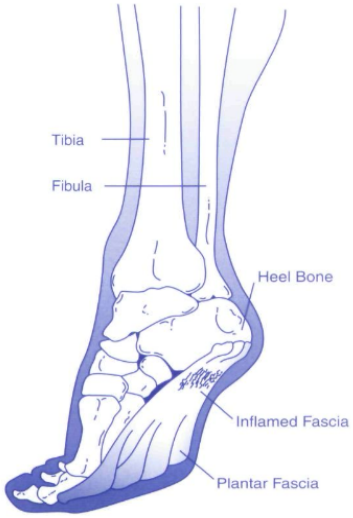


Figure 1: Location of the plantar fascia [1]

Understanding the pattern of pressure distribution during everyday activities not only provides a background to the development of musculoskeletal disorders related to the foot such as plantar fasciitis, but also plays a role in proactive approaches to injury management and treatment.

As such, the current market interested in this type of research incudes:

- Physician
- Pedorthists & podiatrists
- Footwear designers
- Research in biomechanics

CURRENT METHODS & DEVICES

Razak et. al. [7] have categorized the realm of plantar pressure measurement systems available in the market: platform floor based systems and insole based system. These systems are depicted in figure 2 below.

Figure 2: Platform based plantar pressure measurement system (shown left) and insole based system (shown right) [8]

Platform based systems are embedded with a matrix of pressure sensors, and have the advantage of higher resolution, and ease of use. However the nature of the platform system limits its use to the laboratory. In sole based systems allow for a degree of portability, and allow to study the dynamics of pressure distributions inside of a shoe, indicating it's

importance in orthotic and footwear development. The instrumentation of either system has seen the use of, but is not limited to, light deflection, capacitive transducers, force sensing resistors, and hydrocells.

Outlined below in Table 1 are details about some of the current technologies utilizing portable insole systems :

Table 1: Examples of Systems currently available for consumers

F-Scan by Tek Scan

A portable system to measure plantar foot pressure and can transmit up and store data wirelessly from a maximum of 100 meter distance. The F-scan uses force sensing resistors as it's sensing unit, offering a resolution of 25 sensing units per square inch. [9], [10] The data would then need to be transmitted to a computer for analysis and result production.

Pedar (c) by Novel

The Pedar System is an "in-shoe dynamic pressure measuring system" [11] that also measure plantar pressure on the foot. The information as to the technical specifications for the systems or pricing was not published.

Parotec Pressure Measurement System

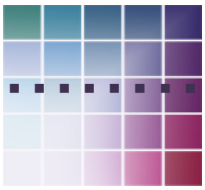
The Parotec is yet another pressure measurement systems that relies on hydrocells to produce a pressure sensing grid.

OBJECTIVES

There is several portable pressure sensing products currently available in the market. PresTrack's primary goal is to provide a product with a comparable portability and functionality while reducing the retail cost.

Based on preliminary research, even the cheapest pressure sensing system runs for $10,000, running up to $25,000 retail value. By offering an economic system that has comparable functional specifications, we offer the opportunity to increase the efficiency of large scale research.

PresTrack's goal is to design a system that will be able to successfully analyze the pressure distribution on the subject's feet using a grid-like structure of piezoelectric wires.



Our key objectives are:

1. **Safety:** Providing a safe and reliable shoe insert, and alerting consumers to potential risks associated with the use of PresTrack *Plantar Foot Pressure Analysis System*.
2. **Cost:** Delivering a cost effective product that can compete with current products while delivering accurate results.
3. **Usability and Reliability:** Following in from the cost effectiveness, we want to create a product that is reliable and can be easily used by both researchers and also the mainstream consumers.
4. **Comfort**: Offering a product that is comfortable to wear for the consumer.

PROJECT SCOPE

PresTrack will develop a *Plantar Foot Pressure Analysis System,* which is a reusable device intended to be designed as a shoe insert, with a wearable microcontroller unit capable of storing and analyzing received data. The insole will be limited to closed toed shoes capable of accepting a shoe insert. Our design will enable customization for various shoe sizes, and will also allow for an easy setup.
The scope of what our project will be able to do is outline below in figure 3.

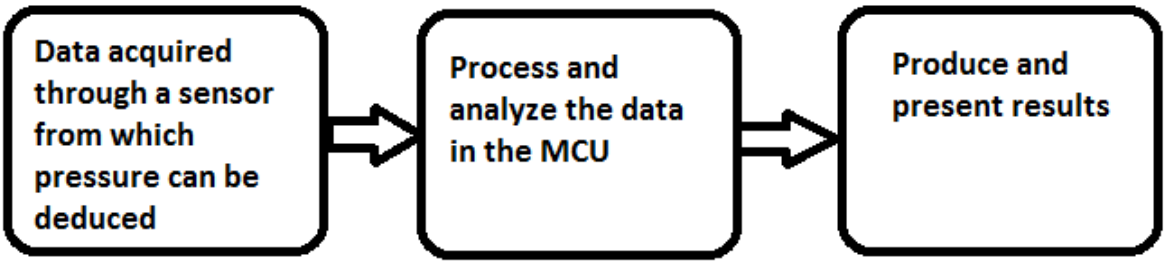


Figure 3: Project Scope

Details of what each of these areas will encompass and the underlying design is described in the following Overview section.

OVERVIEW

The project we propose to deliver will have 3 main parts: a pressure-sensing insole, a data collection unit, and accompanying PresTrack *Plantar Foot Pressure Analysis System* software.

Pressure Sensing Insole

The pressure-sensing insole will consist of a pressure sensors align in a gird fashion as shown in figure 4 below. To ensure that the wearer maintains a normal gait during data collection, the pressure sensing matrix will be embedded in a soft lignin that.

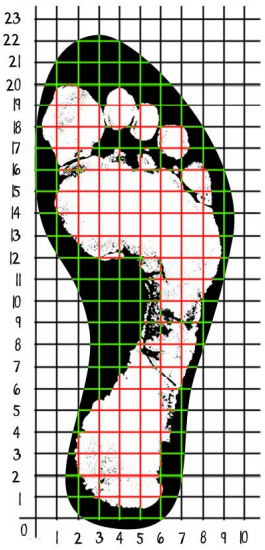


Figure 4: The mesh grid made of piezoelectric wires on a shoe insert. The x and y axes are placed to identify corresponding the row or column of a particular point.

Data Collection Unit

From the pressure-sensing matrix, the leads from the sensors will be integrated in the data collection unit. It will consist of:

- A battery source
- an on/off switch
- a data acquisition board
- microcontrolling unit
- an SD card for data storage and download onto personal computer or handheld device for analysis within the accompanying PresTrack *Plantar Foot Pressure Analysis System* software

PresTrack Software

The software will be the main interface the user has with the data controlling unit. The functions of the PresTrack *Plantar Foot Pressure Analysis System*:

- Allow the user to set limited parameters for testing
- Allow the user to download the data from the mounted SD card of the data collection unit
- Analyze the recorded data, and present it in an easy to understand format for the user

COST BREAKDOWN

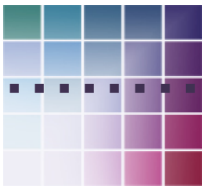
The estimated costs of the materials used for developing PresTrack's *Plantar Foot Pressure Analysis System* is detailed in the table below. The costs highlighted below also takes into account discrepancies in pricing so is priced 15% above market value.

Table 2: Breakdown of Costs associated with Proof of Concept

Item/Product	Cost
Microcontroller	$100
DAQ board (around 70 to 80 inputs)	$200
SD Card and reader	$24
Battery	$30
Metallized Piezo Film Sheets	$300
Shoe inserts	$30
Other Electronic components (wires, lights,)	$100
Casing for the microcontroller	$100
Other (unforeseeable costs)	$100
Total	$984

The costs outlined above are estimates and do not depict the actual cost of the final product. This discrepancy is accounted by the resources expended for research purposes. The research allocated is to identifying the appropriate foot sensor with the right resolution, size and durability.

SOURCES OF FUNDING



The project has received its starting components from SFU Engineering is looking to receive funding from the Engineering Student Society Endowment Fund (ESSEF). We also will be applying for the Wighton Fund to cover any additional costs. All remaining costs will be covered by PresTrack.

Table 3: Timeline of events

Bold indicates major milestones

Date (M/DD/YYYY)	Task
1/20/2014	**Submission of Proposal**
1/21/2014	Part & Components Research
1/21/2014	Testing of Rudimentary Design Concept
1/24/2014	**Submission of Funding Proposal to ESSS**
1/28/2014	ESSS Funding Proposal Defense
1/30/2014	**Ordering of Parts**
02/09/2014	Validation, Verification, & calibration of parts and components
2/10/2014 - 2/14/2014	Preparation of DAQ and Microcontrolling unit
2/17/2014	**Functional Specification Due**
2/26/2014- 3/5/2014	Debugging, Trouble shooting, and in general buffer time
3/1/2014	PresTrack Software development begins
3/7/2014 - 3/16/2014	Integrating sensor unit and microcontroller unit
03/10/2014	**Design Specification Due**
3/17/2014 - 3/24/2014	Integrating sensor/microcontroller unit to GUI and software
3/19/2014- 3/26/2014	Presentation PowerPoint and remaining documents to be completed
3/24/2014	**Written Progress (time estimate)**
3/26/2014	Project Delivery for Presentation (Group Deadline)
04/02/2014	**Demo of Proof of Concept**

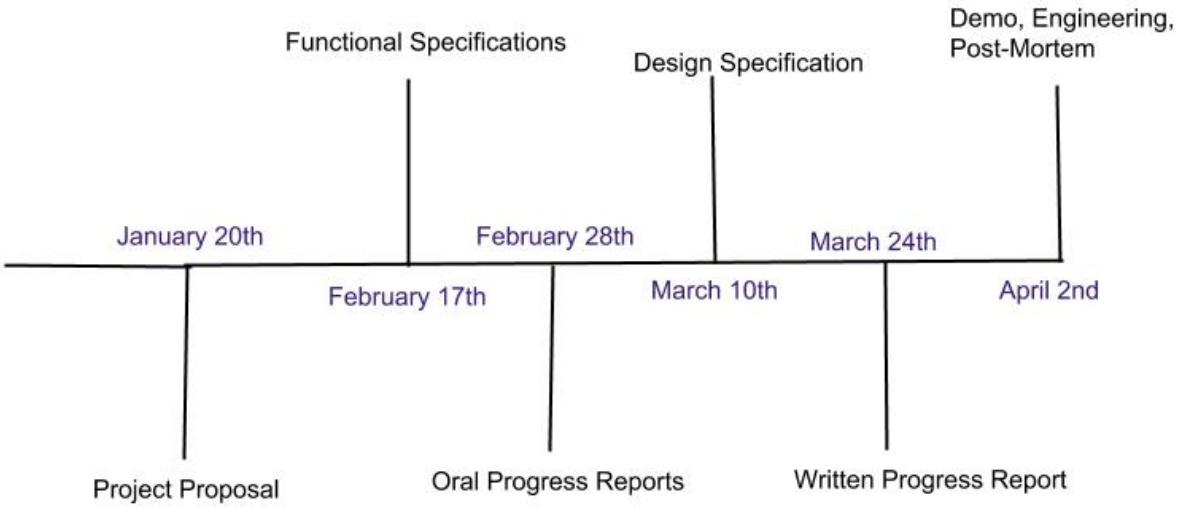


Figure 5: Major Milestones

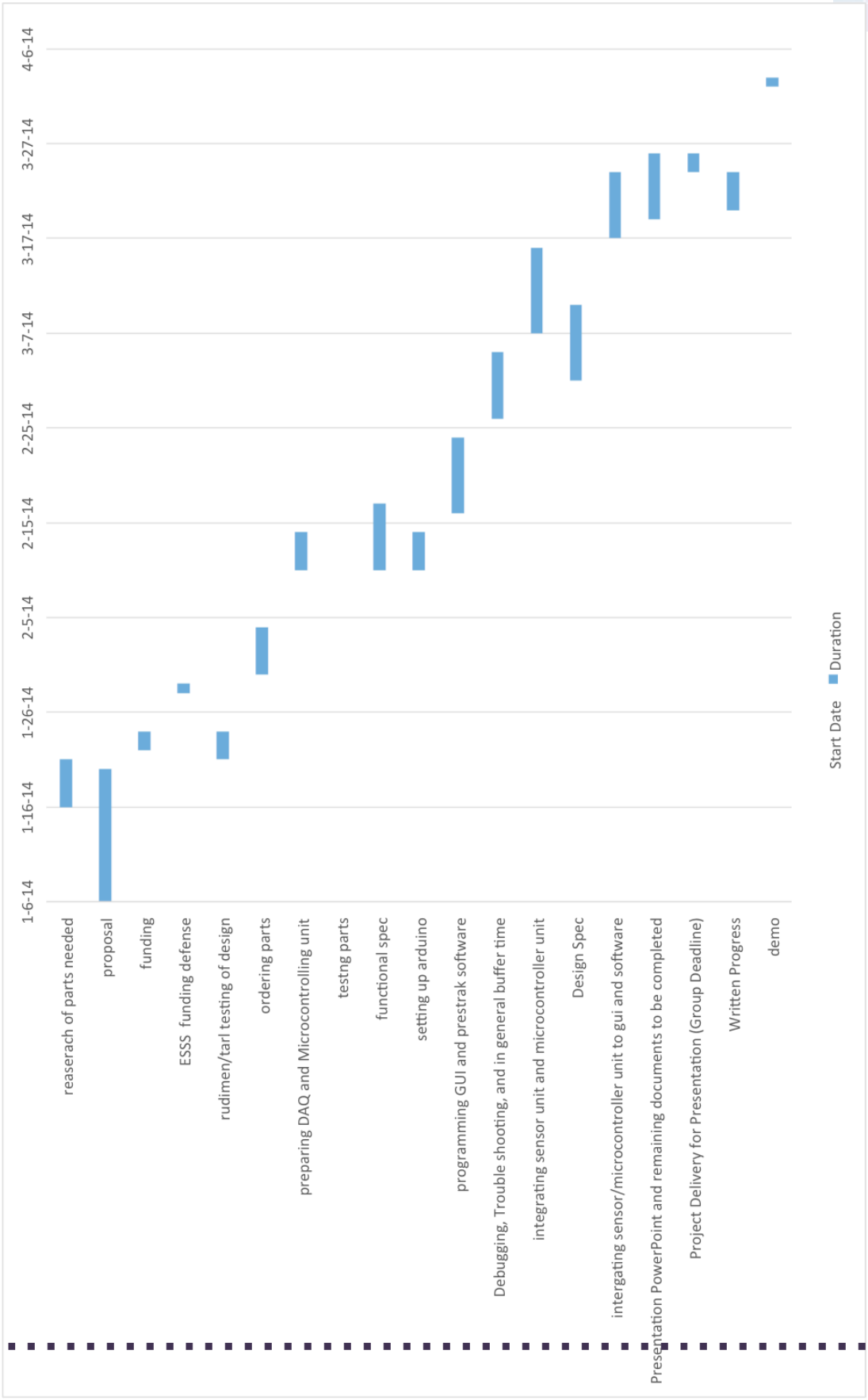


Figure 6: Timelime

RIDDHI BHIDE (CEO)

Riddhi Bhide is a fifth year Computer Engineering student at SFU. Her passion for integrating medical sciences with technology has allowed her to explore various areas in computation to see their applications in the biomedical field. Courses in programming, embedded systems and electronics as well as consistent involvement in various extra-curricular activities related to engineering allow Riddhi to have a strong technical knowledge as well as the people skills required to fully understand customer needs.

MONA LISA DELVA

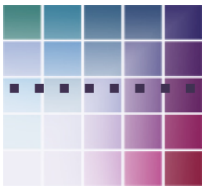
Mona Lisa Delva is in the final year of study of a dual major program combining Kinesiology and Biomedical Engineering with Honors. Mona Lisa offers a particular specialty of skills relating to lower limb mechanics through her previous work with Kintec Footlabs. At Kintec Footlabs, she was in a unique position to study many of the underlying causes of plantar fasciitis, as well as the most effective treatments and devices for patients. Combined with a technically background in programming and electronics, Mona Lisa helps solidify the transition between the "tool user" & the "tool builder".

ROHINI ISHWARIYA

Rohini Ishwariya (Chief Financial Officer) is a fourth year Biomedical Engineering Student at Simon Fraser University (SFU). Rohini has acquired her unique set of interdisciplinary skills through the combination of strong academic and extracurricular activities. Her academic record depicts a strong background in mechanical hardware and design specification, attributed to successfully completing several projects in designing, construction, functionality of haptic robotic systems. Additionally, she has worked on several projects in analog and digital electronic design and control systems. Moreover, her involvement with EWB as the financial officer affirms her credibility to uphold her position as the CFO of PRESTRACK.

TENGETILE MHLANGA

Tengetile Mhlanga is a fifth year Biomedical Engineering student at Simon Fraser University. Her passion for technology as a medium to improve healthcare influenced her to her choice to pursue this degree. As a senior student she has acquired programming skills, electronics knowledge as well as CAD skills. Her co-op as a research assistant at the



Head Injury Prevention Lab allowed her to further hone these skills as well as improve her research methods. She will therefore act as the PRESTRACK Chief Technical Officer (CTO)

NAVJOT RANDEV

Navjot Randev (Chief Creative Officer) is a fourth year Electronics Engineering student at Simon Fraser University (SFU). Navjot worked in Recon Instruments as a part of the Research and development team, amongst her various duties she was responsible for the fine prototype development which involved micro soldering on S02 and S04 boards. Additionally, her research on technologies for information augmentation reinforced her understanding of the design requirements of a system. She is also experienced in programming microcontroller and android app development and is particularly keen in the development of assistive medical devices. The industry experiences along with the various course and project experiences obtained through her academic career enables Navjot to be equipped with the skills to be the Chief Creative Officer of PRESTRACK.

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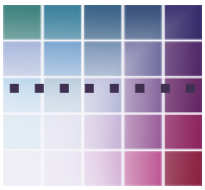

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